temperature service performance. Additionally, these alloys exhibited other favourable features such as good corrosion resistance and oxidation resistance, together with maintenance of good ductility after brazing. The extensive use of various gold-bearing brazing alloys by aero-engine manufacturers indicated that these materials would exhibit satisfactory metallurgical characteristics both during brazing assembly operations and under extended service conditions. None of the available gold-bearing braze alloys have melting temperatures above the temperature of the "torching flame" and after consideration of the various possibilities the 82Au-18Ni eutectic alloy was selected for initial evaluation of both its brazing characteristics and its performance during the "torching flame" tests. While this alloy was not one of the alloys within the higher melting-point range, its melting point is about 170°C above that of the silver-copper alloy.

The brazing trials with the 82Au-18Ni brazing alloy and the 21Cr-6Ni-9Mn and 14Cr-5Ni stainless steels showed the materials to be completely compatible. Brazing at excessively high temperatures and for an extended time, showed general, smooth contoured, dissolution of the stainless steel parent materials with no evidence of intergranular penetration nor any evidence of the formation of intermetallic compounds.

Stainless steel specimens of identical configuration to those previously used for the "torching flame" test were then produced using the 82Au-18Ni braze alloy. When subjected to the "torching flame" test with full hydraulic pressure applied, these specimens survived the minimum design requirement time of direct flame impingement with no sign of distress. As a result of these tests, and the preceding metallurgical assessment, the use of stainless steel tube and machined fittings brazed with the 82Au-18Ni braze alloy has been established for use in the Concorde airframe hydraulic system in the engine bay region.

With the use of the 82Au-18Ni brazing alloy for these applications there have arisen two features which are of benefit in monitoring product quality during manufacture. The high density of the gold in the braze alloy clearly reveals the presence of the 82Au-18Ni alloy on radiographic examination, which assists in the interpretation aimed at confirming that the correct procedures have been followed, and highlights any lack of uniformity of the braze film. Dissolution of the parent materials enlarges the volume over which the gold content is distributed and provides a continuous monitor of the maintenance of procedures and correct functioning of the brazing equipment. Additionally, the differences in density between the titanium alloys and stainless steel materials (tubes and machined fittings) and the various brazing alloys provide a continuous monitor, during radiographic examination, on the correctness of the materials in the various assemblies.

By utilising these various materials and brazing alloys, relative to the specific applications existing in Concorde, an optimum weight-cost-design concept has been achieved. This, together with the direct confirmation that the correct procedures and materials have been used, engenders a high level of product quality and reliability.

Ultrasonic Wire Bonding of Gold

A three-year programme of work designed to improve the quality and reliability of ultrasonic welds between aluminium or gold interconnection wires and thick-film circuit materials, sponsored by the British Ministry of Defence, has been completed at the Welding Institute. The full report, by K. I. Johnson, M. H. Scott, and D. A. Edson, remains confidential to members of the Institute, but the broad conclusions arrived at are of considerable interest to the semiconductor industry.

To monitor the variables in ultrasonic bonding, a light cell-fibre optic system was attached to the welding machine to measure the small high-frequency vibrations. In use this device emphasised the problem of obtaining reproducible bonding conditions on a number of welding machines and showed the value of calibrating their output with this or some similar monitor.

Wedge bonding of aluminium wires to three thick-film materials—palladium-silver, palladium-gold and gold—was more difficult and critical than to aluminium thin films, and the palladium-gold was more troublesome than the others, possibly due to differences in hardness. Wedge weld strengths were dominated by the thinned section at the edge of the weld—a factor possibly sensitive to tool profile—whereas in ball or nail-head jointing the wire is welded where it is locally enlarged by the balling.

In the case of ball bonding, conditions were naturally found to be much more tolerant for the three thick-film materials tested, although higher energies were needed for the alloy layers.

Unfortunately, of course, ball bonding is possible only at one end of the lead wire, the other being joined by a type of wedge bonding. Although in the examples given this latter process applied a much greater deformation than for the aluminium wedge bonding, a much greater tolerance was obtained with gold, especially when vibrating along the wire axis. None the less, the gold wedge bonds can be found to be suspect even under optimum conditions. But over-all the report clearly brings out the greater flexibility, tolerance and consistency of the nail-head bonding of gold.

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